22 may be coupled to external radio parts for sending or receiving signaling via circuitry such as integrated circuitry.

[0036] Electronic devices implementing these aspects of the invention need not be the entire devices as depicted at FIG. **3**, but exemplary embodiments may be implemented by one or more components of same such as the above described tangibly stored software, hardware, firmware and data processor.

[0037] Various embodiments of the computer readable MEMs **20**B, **21**B, **22**B, and **24**B include any data storage technology type which is suitable to the local technical environment, including but not limited to semiconductor based memory devices, magnetic memory devices and systems, optical memory devices and systems, fixed memory, removable memory, disc memory, flash memory, DRAM, SRAM, EEPROM and the like. Various embodiments of the DPs **20**A, **21**A, **22**A, and **24**A include but are not limited to general purpose computers, special purpose computers, microprocessors, digital signal processors (DSPs) and multi-core processors.

[0038] It is noted that the communications and/or operations as described below for FIG. **3** are non-limiting to the exemplary embodiments of the invention. The devices and the related operations are merely illustrative of devices for use in practicing the exemplary embodiments of this invention. Any of these operations can be performed using any suitable device including any of the devices shown in FIG. **3**. Further, the operations as described below may be performed in a different order and/or by different devices than what is described.

[0039] The exemplary embodiments of the invention provide at least a novel method and apparatus to share and coordinate responsibilities of LTE PDCP and/or RLC protocols between LWAC and eNB as part of the aggregation. LWAC shall host LTE PDCP, maybe also RLC (depending on standardization/implementation, e.g. if common LTE RLC is used for LTE and Wi-Fi then LWAC may handle also RLC protocol). Further LWAC and eNB may coordinate activation and usage of PDCP and RLC in eNB and LWAC elements. For example when aggregation is activated, LWAC PDCP handles PDCP operation and delivers data over LTE and Wi-Fi where eNB PDCP remains unused (LWAC PDCP interfaces directly eNB RLC API) or operates in transparent mode (to stay in sync of delivery and optionally assist RLC locally).

[0040] The exemplary embodiments of the invention provide benefits which also include that an LWAC or eNB may monitor LTE and Wi-Fi performance in order to be able to maximize usage of the two radios. For example in case one of the radios starts performing poorly LWAC may decide to deactivate usage of the radio for a UE.

[0041] In accordance with the exemplary embodiments existing macro eNB HW can be used as part of the aggregation, only SW update is needed to support cooperation with LWAC. Wi-Fi user plane traffic as part of the aggregation is not routed via eNB but via the LWAC which can be based on e.g. RNC or PGW HW providing plenty of processing capacity. Despite that LTE/Wi-Fi aggregation operates in optimum level and the operations are shared between LTE and Wi-Fi models (e.g., see of approach labelled as DC-**1***a* of FIG. **2**B and approach labelled as DC-**3**C of FIG. **2**A) the exemplary embodiments can provide benefit for aggregation capable networks. Further the same principles and mechanisms could be utilized for LTE Dual Connectivity to relax macro eNB performance requirements when sending data to UE over macro and small cells eNB.

[0042] Referring to FIG. **4** there is shown a network architecture to support cellular network/Wi-Fi aggregation with existing networks when (e.g., **3**C or **3**D) aggregation alternatives are used for a non-collocated model. It is noted that any reference in this paper to a particular cellular network carrier or technology, such as an LTE carrier or technology, is non-limiting. In accordance with the exemplary embodiments of the invention a cellular network carrier or technology which may be used can be any cellular network carrier or technology, including but not limited to LTE, 4G, 5G and future cellular network carriers or technologies operating in a licensed and/or unlicensed spectrum. Further, in this regard the reference to the LTE/Wi-Fi aggregation controller is none limiting for similar reasons. The LTE/Wi-Fi aggregation controller may be used for any cellular network carrier or technology and is not limited to long term evolution (LTE) use.

[0043] FIG. **5** shows an example protocol and function distribution, and operation of relevant elements in accordance with the exemplary embodiments. NOTE the same architecture could be used also as part of LTE Dual Connectivity technology (dc), which however is not handled in detail in this document (same procedures could be reused for DC to relax eNB performance requirements for that as well). FZ AP means Flexi Zone AP with LTE pico and Wi-Fi radios.

[0044] FIG. **5** describes one potential scenario for LTE/Wi-Fi aggregation where LTE PDCP (with some enhancements on top of existing PDCP) is used commonly on top of LTE and Wi-Fi radios. In this scenario LTE eNB uses a normal existing LTE RLC protocol. It is noted that Wi-Fi has RLC' which performs necessary functions allowing LTE PDCP to operate, for example notifies PDCP blocks which couldn't be transmitted over Wi-Fi radio (e.g., lost blocks etc. as RLC is expected to provide reliable radio transmission for selected traffic). Depending on standardized operation, Wi-Fi may be also used in a so called opportunistic mode where RLC' implements mainly an interface to allow eNB/LWAC to transfer PDCP/RLC PDUs to Wi-Fi but without providing feedback e.g. if PDU was successfully transmitted or not to eNB/LWAC. Both modes are covered by the invention. As shown in FIG. **5** at item **1** an MME establishes Dedicated EPS bearer. At item **2** an eNB decides to use aggregation and returns LWAC transport address and TEID to the MME. Here, a decision is made based on at least one of the UE capability, Wi-Fi availability, operator policy, eNB load/RF, Wi-Fi load/RF (if known), QoS profile, application awareness and/or characteristics (e.g. long lasting download, large frequent packets) etc. At item **3** an SAE GW starts sending GTP-U packets to the LWAC related to the dedicated EPS bearer. Then at item **4** the LWAC coordinates aggregation including sending PDCP (or RLC) PDU's to LTE or Wi-Fi (e.g., based on RF, load, throughput, delay etc.) where the Wi-Fi RLC is a new SW block enabling PDCP to operate (e.g., notification of lost blocks, RF, load, performance, and queuing delays etc.). The PDCP may need to perform PDCP PDU retransmission over LTE if reliable transmission is expected and/or if Wi-Fi lost the PDU. Likewise if LTE radio is poor a PDCP PDU might be retransmitted over Wi-Fi. The eNB RLC may have a new API for aggregation and enabling communication with the LWAC or existing PDCP API may be used. eNB PDCP may be bypassed where LWAC communicates directly with eNB RLC or eNB PDCP may operate in "transparent